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(71) Applicant (*for all designated States except US*): VALTION TEKNILLINEN TUTKIMUSKESKUS [FI/FI]; Vuorimiehentie 5, FIN-02150 Espoo (FI).

(72) Inventors; and
(75) Inventors/Applicants (*for US only*): SUOKAS, Esa [FI/FI]; Nikinkatu 25 C 6, FIN-33580 Tampere (FI). PORRASSALMI, Päivi [FI/FI]; Basaböleentie 8, FIN-10820 Lappohja (FI).

(74) Agents: HAKOLA, Unto et al.; Tampereen Patenttitoimisto Oy, Hermiankatu 6, FIN-33720 Tampere (FI).

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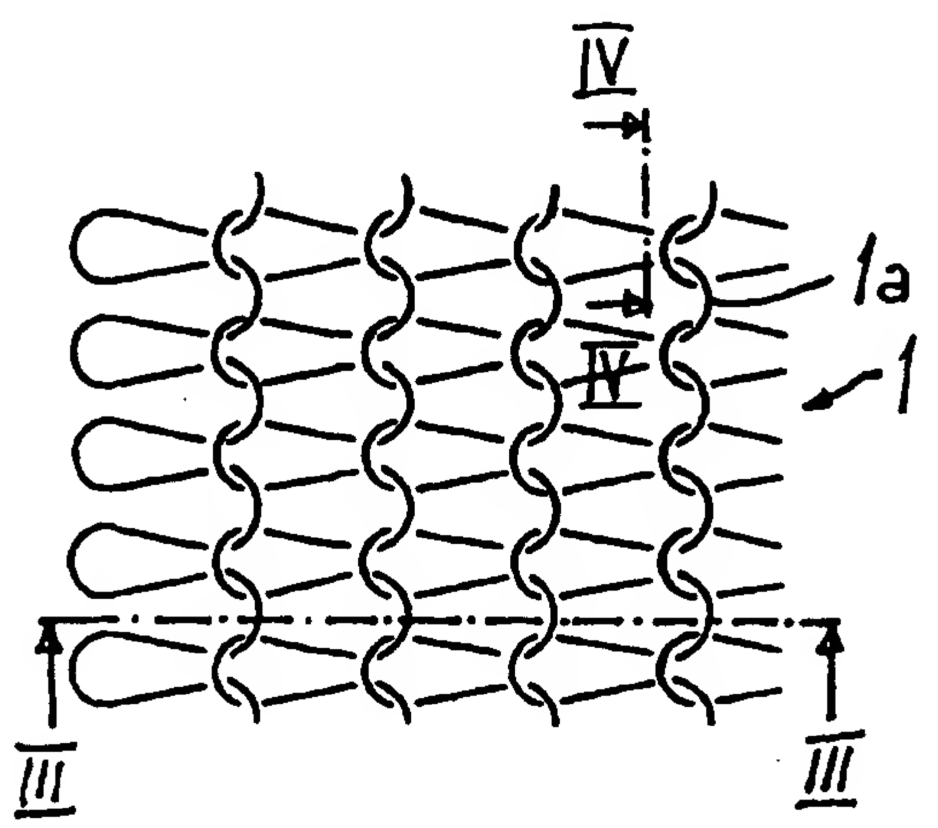

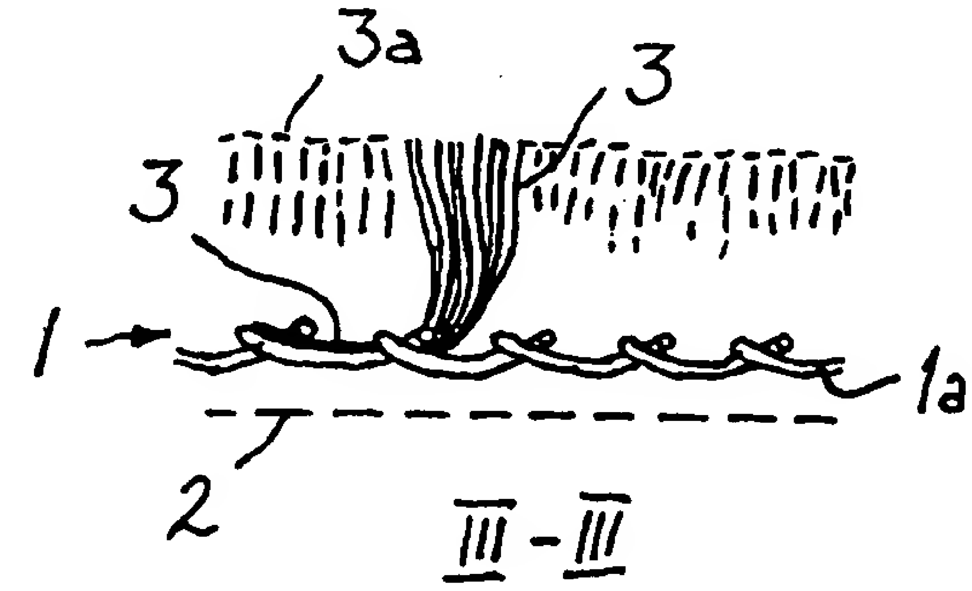

(57) Abstract

The invention relates to an artificial fur, in which staple fibres (3) are mechanically mixed to a base knitted fabric (1) formed of a yarn (1a), to protrude from the level of the base knitted fabric (1) and to form a pile on the outer surface of the artificial fur. The staple fibres (3) mixed to the base knitted fabric (1) are fixed to the base knitted fabric (1) by thermal binding by means of a plastic material softened and/or melted by the effect of heat.

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Artificial fur and method for its manufacture

The invention relates to an artificial fur as set forth in the preamble of the appended claim 1. The invention also relates to a method for the manufacture of an artificial fur. The following is a description on the use of the artificial fur and its known manufacture and structure.

Use of artificial fur

Artificial fur is a knitted pile fabric. It is a soft, bulky, light-weight and heat-insulating product. Conventional uses of synthetic fur (high-pile or sliver pile) are the linings of outdoor clothing and shoes. Technical applications include upholstery materials for furniture, technical products used in hospitals, polishing wheels and paint rollers. By increasing the basis weight of knitted pile fabric, it can be used to manufacture either suede fur coats, in which the pile is directed to the inside, or artificial fur coats, in which the pile is directed to the outside. Because the outer surface of suede fur coats is a plain knit, it can be dyed to various patterns.

Manufacture of artificial fur

The mechanical bonds of the fibre materials in the artificial fur are prepared directly with a knitting machine. In practice, the artificial fur is manufactured with a single-cylinder circular knitting machine. The yarns of the base knit are fed to the latch needles of the cylinder, to which is also supplied the sliver consisting of staple fibres. The staple fibres adhere to a doffer roll which combs the fibres to the correct direction and delivers them to the needles of the knitting machine which have been lifted to receive the fibres from the roll. To ensure the retention of the fibres in the needle hooks, and their orientation, air is blown through a narrow slot to the feeding point towards the centre of the cylinder of the circular knitting machine. When the needles begin to descend with the tufts of staple fibres attached to them, the loop yarn which forms the actual knitted fabric is fed to the needles. After the needles have descended through the loops of the preceding course, the loop yarn binds the tufts of staple fibres with the plain knit in such a way that they

form a fur-like cover. Particularly the step of knitting to accomplish the bond of the artificial fur is described in European patent 0 091 025 and international publication WO 95/25191.

Further, patent publication DD 122 558 discloses a method for manufacturing a textile structure resembling a fur, in which the textile-technical bond between the fibre material which constitutes the pile and the base knitted fabric is accomplished with a sewing knit technique (German *Nähwirktechnik, Nähwirken*) which is a technique differing from the methods of manufacturing of artificial furs effected in knitting machines. Here, the pile is produced by means of sewing yarns punched with needles through the base material and forming, on the other side of the base material, protruding loops which can be opened by cutting. A second textile layer is attached, for example by means of a heated film, to the yarn on the reverse side of the base material constituting of woven fabric, after which the fabric can be pulled off in the direction of the pile fibres, whereafter the pile fibres formed of the above-mentioned sewing yarns remain attached to the film on the outer surface of the product.

Pile textile products manufactured by the above-mentioned sewing technique are also described in application publication DE 1 938 970. Before the sewing knitting, a second non-woven fabric or film of a thermoplastic material is placed on top of the base material, and yarns are punched through the resulting layered structure. When the base material is heated, the thermoplastic material which is present as an auxiliary layer therein is made to melt and bind the pile consisting of the sewing yarns better to the base material.

When artificial furs are manufactured with a knitting machine, the pile formed of staple fibres is attached mechanically at the knitting stage, and therefore the bond is not strong. For this reason, the staple fibres are bound to the base knitted fabric, according to the knitting machine technology of prior art, by adding a substance which fixes the pile to the fabric.

In adhesive bonding of artificial furs, a fluid dispersion adhesive is generally used, consisting of a continuous water phase and a dispersed polymer phase which can be solid or liquid. When applied, the adhesive will partly penetrate into the structure as well. Normally, the pile of artificial fur is glued with a latex, in which polyvinyl acetate (PVA) is dispersed as a binder in the water phase. Other binders include *e.g.* polyolefins (PO), copolymers of polyamide (PA), polyesters (*e.g.* coPET), or polyvinyl chloride (PVC). The adhesive can also be a paste, wherein a large quantity of powder-like ethyl-vinyl acetate copolymer (EVA), polyethylene (PE) or copolyamide (coPA) is mixed in the water phase. Also bicomponent adhesives are used, such as urethane adhesives whose components are isocyanate and polyol. Also these adhesives are well-flowing, liquid, and they penetrate into the structure.

A stabilized latex or paste is applied onto the flat side of the artificial fur for example by applying foamed adhesive with a wiping blade. The penetration of the adhesive in the fabric structure is controlled with surface-active agents. After this, the artificial fur is guided to a frame in which the adhesive layer is thermally fixed. The flat surface of the glued artificial fur feels hard, which is due to the stiffness of the fixed polyvinyl acetate layer.

Furthermore, US patent 4,236,286 presents the binding of pile to a knitted fabric by means of a thermally hardenable coating.

If a suede fur coat is made of a pile fabric, its glued flat surface can be dyed. The dye is applied onto the flat side of the artificial fur, after which the binder is thermally fixed in a frame. Pigment colours with the associated binders make the feel of the product hard.

The glueing step requires separate devices for the processing of fluid dispersion adhesives, such as devices for preparing the adhesive for dispensing and devices for dispensing the adhesive. Moreover, the adhesive has a harmful effect on the structure of the artificial fur, for example the feel is impaired.

It is an aim of the present invention to present an improvement to the above drawbacks and to present an artificial fur which has a better structure and is suitable for various uses as well as or better than structures of prior art and which is also easier to manufacture. To achieve this aim, the artificial fur is primarily characterized in what will be presented in the characterizing part of the appended claim 1. By utilizing in the fixing a plastic material which is melted or softened by the effect of heat and which can be a structural fibrous element in the artificial fur (in the staple fibre or in the yarn) or a layer or a part of a layer added on its back side, it is possible to provide the artificial fur with properties which are closer to its fibrous structure without extra adhesives or the like. At the same time, glueing devices are avoided, and they can be replaced by heating devices, which are less complex.

In view of other preferred embodiments of the invention, reference is made to the appended dependent claims and the following description.

In the following, the invention will be described with reference to the appended drawings, in which

Fig. 1 shows, in a flow chart, a method for manufacturing a pile structure according to the invention,

Fig. 2 shows one step of the manufacture of a pile structure in a schematic view,

Fig. 3 shows a base knitted fabric in a planar view and a finished artificial fur in a cross-sectional view,

Fig. 4 shows a detail in an artificial fur structure, and

Figs. 5 to 10 show results of tests on the invention.

The process according to the flow chart of Fig. 1 comprises the following steps: A) the feeding of a yarn of the base knitted fabric and the feeding of staple fibres forming the pile, B) the formation of the pile by fixing the staple fibres mechanically to the base knitted fabric in

connection with its formation, C) the shearing of the outer surface of the pile permanently to the length and possible mechanical treatment of the pile, D) thermal treatment to fix the pile to the base knitted fabric, and E) further processing.

Figure 2 shows an example of the manufacture of the artificial fur. The base knitted fabric is made by feeding yarns 1a of the base knit to knitting machine latch needles 4, to which are also fed staple fibres 3 from a doffer roll 5, to form the pile. This stage of operation has been described in more detail above under the heading "Manufacture of artificial fur", and the relating technique is described in European patent 0 091 025 and in publication WO 95/25191.

Structures of artificial fur

In this context, the following terms will be used:

- Fibre material: staple fibre or filament. Fibre material is also considered to include microfibres which have become common in the textile industry. According to a definition established in Europe, microfibres are fibres of less than 1 denier, but elsewhere, the upper limit is considered to be 0.7 denier.
- Staple fibre: fibre material (staple) consisting of several discontinuous fibres with a defined, limited length or length distribution, also including fibres with the thickness of the microfibre class.
- Filament: continuous fibre as opposed to staple fibre, also including fibres with the thickness of the microfibre class.
- Yarn: yarn formed of staple fibres or one or several filaments.

Figure 3 shows the structure of artificial fur. On the left hand side, a base knitted fabric 1 is shown on the back side, and on the right hand side, the artificial fur is shown, in a cross-section taken in the direction of the base knit wales perpendicularly to the plane of the artificial fur. The cohesive structure of the pile of the artificial fur is the base knitted fabric 1 which consists of lengths of a yarn 1a fed to the needles of a knitting machine. In the figure, the yarn lengths form successive courses of a plain knit. Staple fibres 3 protrude from the level of the base knitted fabric, which originate from tufts of fibres fed in the above-

described manner to hooks of the needles of the knitting machine and whose free ends are oriented to the front side of the base knitted fabric 1, forming a more or less dense pile depending on the density of feeding of the staple fibres 3. The fibre tufts are fixed to the base knitted fabric in the form of bends running together with the loops, always tied by the next loop in the order of formation of the loops, and their both ends always stick out through the previous loop on the back side of the knitted fabric. The original length of the pile, *i.e.* the greatest possible distance of the front surface of the artificial fur from the base knitted fabric 1, naturally depends on the length of the staple fibres 3. The pile is sheared to the length normally by cutting the ends of the staple fibres, wherein a relatively even outer pile surface 3a is obtained, as shown in Fig. 3. In connection with the shearing, the staple fibres can still be oriented to a desired direction, for example more upright. There are also other methods for mechanical processing of the pile, which can be effected to achieve a desired structure or appearance for the pile.

Further, Fig. 3 shows, indicated with a broken line, an additional layer 2 which is possibly fixed on the other side of the base knitted fabric 1, *i.e.* the reverse side of the artificial fur, the possibilities for forming the additional layer 2 being discussed below.

The pile formed of staple fibres 3 is fixed permanently to the base knitted fabric 1 by means of a plastic material which can be melted or softened by the effect of heat; that is, the structure of Fig. 3 contains plastic material which, after thermal treatment, has been melted or softened to such an extent in a location where the staple fibre 3 is in contact with the base knitted fabric 1 that the staple fibre has adhered to the yarn 1a of the base knitted fabric 1 by means of the plastic material which has melted/softened and solidified again after the temperature has sunk. Figure 4 shows a cross-section of the artificial fur along the line IV—IV of Fig. 3, *i.e.* in a direction perpendicular to the wales, and such binding plastic material present at the points of contact of the staple fibres and the yarn is indicated with the reference B. The material area B can consist of plastic material in the staple fibres 3, plastic material in the yarn 1b of the base knitted fabric 1, or

amalgamated plastic material in both. In a corresponding manner, the material area can originate from the surface material of an additional layer 2 which is against the yarn 1a of the base knitted fabric and the staple fibres 3 at their point of contact.

The meltable plastic material can be a binding fibre or a part of a binding fibre, or thermoplastics used as general structural elements for textile products, which can be in fibre form or be structures with a wider area, such as films.

Binding fibres

When a thermally bondable plastic material is selected for a product, the maximum temperatures prevailing in the conditions of its use and maintenance must be taken into account. Most commonly, the basic polymers for thermally bondable fibres are polyesters and polyamides. The softening and melting points of some polymers are given below:

— polyvinyl chloride/PVC:	T_S = 115—160°C;	T_m = 160—180°C
— polyamide/PA:	T_S = 170—190°C;	T_m = 210—230°C
— polyester/PET:	T_S = 230—240°C;	T_m = 245—260°C
— polypropylene/PP:	T_S = 150°C;	T_m = 160—170°C
— polyethylene/PE:	T_S = 85—90°C;	T_m = 115°C

Of these, on the basis of the temperature behaviour, suitable binding fibres are polyvinyl chloride and polyolefins (polypropylene and polyethylene), including copolymers based on them. However, the melting points of polyolefins, particularly polyethylene, can be too low for some use and maintenance conditions.

In the case of polyamides and polyesters, the melting point of the basic polymers are lowered with comonomers (copolyamides and copolyesters), as a consequence of which binder fibres are achieved.

To make the thermally bondable fibre to adhere firmly to the product to be fixed (*e.g.* knitted or woven fabric), the chemical structure of both of them must be similar. If this basic rule is followed, adhesion problems

are avoided. If the raw material of the basic product is polyester (*e.g.* Dacron or Trevira), the thermally bondable fibre to be selected must be a copolyester, not polyolefin or polyamide. In this way, sufficient strength of the thermal bond between the fibres of different material layers is secured. If the chemical structure of the binding fibre is different from that of the base layer, a compatibilizer must be used to couple the substances together.

The binding fibres to be fixed by heat and pressure can be divided into three different classes, namely adhesion fibres, meltable adhesion fibres, and bicomponent fibres.

Adhesion fibres are normally melt-spinned amorphous polyesters. Due to the lack of crystalline areas, these polymers become sticky on their surface when the temperature rises above 100°C for the first time, wherein they can be calendered to the base material by means of pressure.

The melting point for meltable adhesion fibres must be lower than that of the basic material, to which they are adhered by means of heat. Normally, this temperature difference is sufficiently great, 50 to 100°C, to avoid damage to the basic material. The melting point is in this case usually less than 205°C, preferably less than 180°C. To give the softening and melting points the desired value, the chemical structure of the basic polymer may have been modified synthetically (copolymerization). Such meltable adhesion fibres are normally copolyesters or copolyamides. Homopolymers are also possible, such as the above-mentioned PVC, PP and PE.

In a bicomponent fibre to be used as a binding fibre, two components are combined whose chemical structures are different (*e.g.* PET and PE) or whose melting points are different. An example is a bicomponent polyester fibre whose one area, which is used as the binding agent, melts at a low temperature of 100 to 110°C and whose other area melts at a high temperature of 250 to 265°C.

The above-mentioned binding fibres are available as staple fibres or filaments, and these fibre types can also be used to make a yarn, which can also contain different fibres in a blend.

Product alternatives

In the following, some alternatives to achieve the above-mentioned finally fixed structure will be presented. In the following structures, the plastic material which melts or softens by the effect of heat is present in at least one of the following parts of artificial furs: the staple fibre 3 forming the pile, the base knitted fabric 1, and the additional layer 2. In the following alternatives, the word "meltable" is used to refer to both a meltable and a softening polymer material in which the temperature rises by the effect of external energy applied to in such a way that the above-mentioned phenomena take place and the material enters the adhesive state. There is always a change in the state of the material or in the properties of the surface from the solid state to a state which makes the parts adhere to each other.

A) Meltable binding fibres are blended in staple fibres 3 forming the pile. The content of the binding fibres can vary from 0 to 100 %. The case 0 % refers to alternative D to be described below.

B) A meltable binding filament or yarn is combined to the yarn 1a of the base knitted fabric 1 by multiplication, doubling, double-doubling or another textile technique. The content of binding filaments (mono or multi) or yarns can vary from 0 to 100 %. The case 0 % refers to alternative D to be described below.

C) The alternatives A and B together, *i.e.* the staple fibres 3 have meltable binding fibres and the yarn of the base knitted fabric 1 has a meltable binding filament or yarn.

In the preceding products A, B and C, the binding plastic component, *i.e.* the binding fibre and/or binding filament or yarn is melted or softened by means of conduction, convection or radiation heat and possibly by pressure. Combinations of various melting or softening methods can be used when necessary. From the structures of the products A, B and C, it is also possible to make an artificial fur with pile on both sides

of the product. The pile is first bound mechanically to one side of the base knitted fabric, after which a part of the pile is made in a so-called rowing process to extend through the base knitted fabric to the opposite side. In the rowing (German *Rauhen*), movable carding means are used to pull out fibres from the textile material, *i.e.* in this case pile fibres from the opposite side to the other side of the base knitted fabric.

D) No meltable binding fibres are blended in the staple fibres 3 forming the pile. In the artificial fur, the staple fibres 3 of the pile, or the yarn 1a of the base knitted fabric 1, or both, are formed of thermoplastics used as general structural elements of textile fabrics, whose chemical materials include meltable polyolefins, polyvinyls, polystyrenes, polyacrylnitriles, polyacryls, meltable derivatives of cellulosic polymers, polyesters and polycarbonates, polysulphones, polyimides, polyether oxides *i.e.* polyacetals, polyketones, polyurethanes, polyfluorides, thermoplastic elastomers, such as thermoplastics containing dienes, elastomeric copolymers, such as elastomers containing butadienes, elastomers containing ethylene or propylene, fluoroelastomers, silicon elastomers, or various chemical combination polymers or blends of any of the above-mentioned substances in material, fibre, filament or yarn form. The pile or the base knitted fabric or both, depending on the materials, are melted by means of conduction, convection or radiation heat and possibly pressure. The requirement is that the temperature exceeds the melting point of the thermoplastic and the effect is sufficiently long but at the same time sufficiently short. Combinations of various melting methods can be used if necessary. The pile and the base knitted fabric are bound to each other by melting.

E) A basic product, that is, an artificial fur with pile on one side of the base knitted fabric 1, with no meltable binding fibres blended in the staple fibres 3 forming the pile. On the flat side, *i.e.* the reverse side, of the artificial fur, a film which contains a thermoplastic at least on its surface is laminated as an additional layer 2. The material can be of same materials as mentioned in the alternative D above, or their various chemical combination polymers or blends. The film can be fully of the same

thermoplastic, or it can have a uniform surface layer of a thermoplastic melting at a lower tamperature, or it can have a surface with an adhesive web consisting of fibrous thermoplastic or a spot-gluing pattern whose melting point is lower than that of the actual film. The layer 2 is melted onto the base knitted fabric 1 by means of conduction, convection or radiation heat and possibly by pressure. The film can have special properties, such as it is breathable, in addition to the properties protecting from wind and rain. Combinations of various melting methods can be used if necessary. The film can also be of another material than thermoplastic, if it has any of the above-mentioned thermoplastic structures on the surface adjacent to the base knitted fabric 1. The auxiliary layer 2 can also be a felt which contains thermoplastic at least on its surface, and such a felt can consist of a binding fibre or a blend of binding fibres.

F) The alternative of point A, in which a film or felt is laminated on the flat side, *i.e.* the reverse side, of the artificial fur, having the materials and alternatives of the preceding alternative E. The binding to the base knitted fabric 1 is performed by the methods of the alternative E.

G) The alternative of point B, in which an auxiliary layer 2 is laminated on the flat side, *i.e.* the reverse side, of the artificial fur, having the materials and alternatives of the alternative E. The layer 2 is bound to the base knitted fabric by the methods of the alternative E.

H) The alternative of point C, in which a film or felt is laminated as an auxiliary layer 2 on the flat side, *i.e.* the reverse side, of the artificial fur, having the materials and alternatives of the alternative E. The binding component, *i.e.* the pile fibre and the filament or yarn of the base knitted fabric and layer 2 are bound by the methods of the alternative E.

I) A modified product whose structure can be in accordance with the point A, B, C, D, E, F, G, or H, and in which two artificial furs having pile on one side of their base knitted fabrics 1 are laminated together by means of an auxiliary layer 2, wherein the result is an artificial fur having pile on two sides of the product. The structures of the auxiliary layer and the thermoplastic

materials therein can be in accordance with those mentioned above.

Advantageously, when a heat-bondable fibre material is used in the pile or in the base knitted fabric, some of the material is of meltable/softening plastic and some remains unchanged under binding conditions. These different materials can be in the same fibre (bicomponent fibres) or in different fibres, wherein fibre blends are used in the pile and/or in the base knitted fabric.

The fibre blend may contain thermally bindable fibres and such synthetic fibres which are not changed under binding conditions, *e.g.* thermoplastic fibres with a high melting temperature. The staple fibres 3 of the pile or the base knitted fabric 1 can contain, as other material components in addition to thermoplastics, natural fibres (0 to 100 %) in the pile or in the base knitted fabric (cotton, linen, hare's-tail cottongrass, wool, *etc.*) and thermoplastics, such as thermoplastic coatings, applied after the thermal binding of the pile (dispersion of a polyurethane binding agent, containing colour pigments). On top of the above-mentioned one-sided structures A to I, it is also possible to laminate, or fix in another way, such as by glueing, a fashioned or non-fashioned, natural-fibre or synthetic wovwn or knitted fabric or non-woven fabric or planar (xy-plane) component of textile or plastic technology. All the components of the artificial fur can be dyed or patterned according to known dying methods or graphical printing methods.

When the pile of the artificial fur is thermally bound to the base knitted fabric, the feel of the product is textile-like. At the same time, the pile is bound to the base knitted fabric by melting instead of mechanical binding, that is, the pile of the artificial fur will not shed in use, and the artificial fur maintains its functional properties, such as thermal insulation capacity, important for use. The thermal insulation capability (R_C) of the artificial fur is at least on the level of 0.10 K·m^2/W or better (BS 4745:1990).

Thermal fixing processes of meltable binding fibres

The thermal fixing process must be selected correctly so that the binding fibres would be firmly welded. The melted binding fibres are bound to each other primarily at the intersecting points of contact which are present among the adhesion material and/or between the adhesion and the base materials. In the thermal fixing, the following factors should be considered:

— the principle of the melting process: conduction, convection, and radiation,
— the principle of operation of the melting device: by heat or by heat and pressure,
— the calibration unit: the calibration of the dimensions of the final product,
— the cooling unit: the cooling of the meltable binding fibres, and
— the chemical structure of the binding fibres, the content and quantity of the different components: the properties of the final product, such as the feel and the strength.

If the melting process is based on convection, more precisely on a gaseous medium, usually hot air, the method can be applied by an air flow passing through the product or by surface blowing on the product. The former method is generally used in the manufacture of thick, porous non-woven fabrics, because in this way the fibres of the inner parts can also be heated. The effect of the flow-through is triplicate, but this advantage is lost when the permeability of the product to air is reduced. At best, one- or two-sided surface blowing of hot air is suited for the thermal fixing of the pile fibres of the artificial fur.

When the content of the binding component in the staple fibre blend is increased in relation to the matrix, the bonding strength is increased, although on the cost of the feel. When the content of the bonding fibres is too high, the final product becomes brittle and hard. Better strength is achieved with bicomponent fibres than with single-component adhesion fibres, the volume portion being the same. The final result is also dependent on the number of contact points between the binding fibres as well as on a compression load possibly used.

The pile fibres of the artificial fur are fixed so that the length of the pile (protrusion from the level of the base knitted fabric) is from 1 to 50 mm. The length of the pile of the artificial fur depends on the length of the staple fibre fed and on the adjustments of the pile shearing stage. Staple fibres which contain meltable/softening plastic material are in a card sliver forming the pile, and/or filaments or yarns containing meltable/ softening plastic material are guided to the knitting machine together with the looping yarn.

Other possible methods for thermal binding of the basic product, *i.e.* the artificial fur, include the arrangement of an auxiliary layer 2 on the reverse side by the following methods:

— the technique of laminating plastic sheets which enable a moisture and air barrier,
— the melt impregnation, or coating, of the flat side of the knit of the artificial fur with a plastic melt (*e.g.* a modification of the paper coating process), wherein molten thermoplastic, when solidifying, forms a uniform film which also constitutes a moisture and air barrier,
— the dry impregnation of the flat side of the knit of the artificial fur with a plastic powder and thermal binding in an oven or in a calender, wherein a uniform binding film is also formed.

As a basic rule, it should be stated that there must be a meltable component in both the pile fibre 3 and in the looping yarns 1a of the base knit fabric of the artificial fur, to make these two elements bind well to each other. For the purpose of the invention, it is also sufficient that one of these elements has a meltable component. If a meltable component is present in only one of these elements, it is advantageous that yet another meltable component is introduced with an additional layer 2. If there is no meltable component in either element, the additional layer 2 is necessary to achieve thermal binding.

Advantages of thermal binding compared to glueing

Using meltable/softening fibres and thermal binding in the manufacture of artificial fur, the following advantages are obtained in comparison with conventional adhesives and the like (chemical binder bonding):

— A softer, more textile-like feel is achieved for the final product.
— The final products can be almost fully (100 %) recycled, because the chemical structure of the binding fibres can be selected to be the same as in the base knit fabric or in the woven fabric.
— Energy saving by avoiding the evaporation of water. For melting the binding fibres, thermal energy will only be needed from one quarter to one sixth part (1/4—1/6) when compared with adhesive binding.
— No binder agents or thermal fixing will be needed. The manufacturing process is environmentally safe, because no sewage or exhaust air will be produced.
— By the selection of the binding fibres, it is possible to affect the properties of the final product, *e.g.* flexibility and fire resistance.

EMBODIMENT EXAMPLES

The invention will be discussed in the following examples which are not restrictive.

Tests on thermal binding of the pile

A meltable fibre was added in the pile or base knitted fabric of the artificial fur. In the former case, meltable staple fibres (15 to 50 wt-%) were blended in the card sliver forming the pile, and in the latter case, filaments were guided to the knitting machine with the looping yarn (multiplication or doubling). The tests were made first under very controlled conditions in a laboratory and then in industrial scale. In the tests, the residence times and temperatures were calculated theoretically to make the number of practical tests as small as possible.

The fastening of the pile fibres of the basic product, *i.e.* the artificial fur, was determined by three different methods:

1. The Martindale method, SFS 4328 (Textiles. Determination of abrasion resistance of fabrics. Martindale method)

— determination of the weight loss of the product after loading
— qualitative method

2. The pilling method, SFS 3378 (Textiles. Determination of pilling resistance of fabrics)

— determination of the weight loss of the product after loading
— qualitative method

3. Pile tensile strength test, modified SFS 3189 (Textile floor coverings. Determination of pile withdrawal force)

— measuring the force required for removing the pile fibres from the basic fabric (in Newtons)
— giving normalized results by dividing the force (N) required for removing the pile fibres by their mass (mg)
— quantitative method.

To find out the functionality of the thermal binding, untreated *i.e.* unglued and glued artificial furs were used as reference samples.

Embodiment example 1: Meltable fibre in the pile of the artificial fur, fixing in a hot-air frame

The artificial fur was manufactured with a single-cylinder circular knitting machine. A commercial meltable binding fibre Wellbond TO109 (Wellman International Ltd.) was used to replace part of commercial polyester Dacron T688 (DuPont) used as the pile. Wellbond TO109 is a bicomponent polyester fibre (coPET/PET) whose surface melts at a low temperature ≥ 110°C and core at the high temperature of 255°C. In the thermal binding tests, the basic sample was artificial fur quality T351 with the following structure:

— basic knitted fabric	
· PET 167/32 × 1 ecru	100 wt-%
— pile	
· Dacron T688 (PET) 4.7/35	50 wt-%
· Wellbond TO109 (coPET/PET) 5.3/55	50 wt-%
total	100 wt-%

The meltable fibres were fixed to the polyester fibres of the base knitted fabric in an Ernst Benz continuous laboratory frame. In the final adjustment of the process parameters, the product properties are optimized between the feel and the fastening of the pile fibres so that the level of each is sufficient. The artificial fur containing meltable pile fibres is heated in a Benz continuous laboratory oven whose upper valve (*Klappe*) is open *(auf)* and lower valve (*Klappe*) is closed *(zu)*. The actual test series comprised three different delay times.

The basis weight of the artificial fur was 240 g/m^2. With room temperature (20°C) as the starting point, the temperatures and residence times used in the test series (FRAME) are given in Table 1:

Table 1. Values for air temperature and residence time in FRAME test series.

Sample	Air temperature (real value) [°C]	Sample temperature (target) [°C]	Sample residence time (real value) [s]
Frame 1	160	155	120
Frame 2	180	160	70
Frame 3	200	160	50

The sample was placed the pile side down in a bracket. Further, the artificial fur must be stretched in the sample bracket of the frame in such a way that it is subjected to tensile strength. The pile side of the frame is protected with a heat-resisting material, *e.g.* a cloth with an aluminium coating. Heating with air was effected on the reverse side, *i.e.* the side of the base knitted fabric.

The result of the test is shown in Fig. 5. The first number after the product code T351 indicates the treatment temperature and the second number the residence time. The curves of the pilling test indicate that

the adhesion of the pile of the artificial fur to the base knitted fabric increases with the thermal treatment, but at the same time the feel becomes harder.

Embodiment example 2: Meltable fibre in the pile of the artificial fur, fixing with a hot metal surface

The artificial fur was made with a single-cylinder circular knitting machine. A commercial meltable binding fibre Wellbond TO109 (Wellman International Ltd.) was used to replace part of commercial polyester Dacron T688 (DuPont) used as the pile. Wellbond TO109 is a bicomponent polyester fibre (coPET/PET) whose surface melts at a low temperature ≥ 110°C and core at the high temperature of 255°C. In the thermal binding tests, the basic sample was artificial fur quality T351 with the following structure:

— basic knitted fabric	
· PET 167/32 × 1 ecru	100 wt-%
— pile	
· Dacron T688 (PET) 4.7/35	50 wt-%
· Wellbond TO109 (coPET/PET) 5.3/55	50 wt-%
total	100 wt-%

The meltable fibre contained in the pile of the artificial fur was heated by means of a metal surface. For this purpose, a device was used which has an electrically heated pair of plates (*e.g.* Fixotest). In the final adjustment of the process parameters, the product properties are optimized between the feel and the fastening of the pile fibres so that the level of each is sufficient.

An artificial fur containing meltable pile fibres and having a basis weight of 240 g/m^2 was heated with the middlemost pair of plates in the Fixotest device. Only the upper plate was heated to the adjustment temperature (Table 2). The switch of the lower plate was kept in the 0 position, wherein it was not heated. When the surface of the base knitted fabric of the artificial fur is subjected to a sudden temperature change, heat is conducted to the solid material (conduction)

instantaneously and one-dimensionally. A sudden increase at the initial phase of the moment of effect of the temperature on the surface of the solid material can be calculated to a determined depth, wherein no heat has not yet had time to be conducted to the inner parts of the piece.

The actual test series comprised three residence times (indicated with subindices 1, 2 and 3); at the same time, the quantity of air contained in the artificial fur (porosity) was assumed to be 20 %. The temperatures and residence times of the test series (FIXO) are given in Table 2.

Table 2. Values for delay time dependent on the temperature of hot metal surface in FIXO test series.

Sample	Temperature of metal surface, T_S [°C]	Target temperature of sample, T(0.5,t) [°C]	Time of heating of the sample, t [s]
Fixo 1	160	155	899 = 15 min
Fixo 2	180	160	71
Fixo 3	200	160	22

A sample is placed the pile side down in the Fixotest device, wherein the base knitted fabric of the artificial fur is against the hot metal surface. The hot metal surface melts the meltable fibres contained in the pile to adhere to the base knitted fabric within the calculated time of action. The pile of the artificial fur, in itself, must not melt in any case, because the feel and bulk of the product are impaired. The middlemost upper plate of the Fixotest device is turned against the lower plate, the sample being left therebetween. The sample is subjected to a nominal compression load:

$$P = F/A \qquad (1),$$

in which

$F = m \cdot g$ = force effected by the upper plate
m = mass of the plate (1 kg)
g = gravitational acceleration (9.81 m/s^2)
A = plate surface area ($0{,}05 \cdot 0{,}11\ m^2 = 0.0055\ m^2$).

The artificial fur sample which is freely between the plates of the Fixotest device, is subjected to a pressure whose quantity if 1.8 kPa.

The result of the test is shown in Fig. 6. The first number after the product code T351 indicates the treatment temperature, and the second number the residence time. By means of the hot metal surface, the pile containing meltable fibre can be fixed to the base knitted fabric better than with hot air. When the temperature of the metal surface exceeds the melting point of the binding fibre, the pile does, in practice, not shed from the base knitted fabric.

Embodiment example 3: Meltable fibre in the base knitted fabric of the artificial fur, fixing in a hot-air frame

Meltable binding fibres can be combined to the pile of the artificial fur or the base knitted fabric. In the former case, meltable staple fibres were added to the card sliver (50 wt-%), after which they were melted in a frame (hot air flow). By this method, the same binding strength of the pile and the base knitted fabric was obtained as with a cross-linkable adhesive.

In the latter case, the polyester filament (PET 167f 32 × 2) of the basic yarn of the base knitted fabric was doubled with a bicomponent multifilament yarn (coPET/PET 278f16) in which the surface of single filaments is PET with a low melting point (160—205°C) and core is conventional PET (250—260°C).

The data on the filaments to be combined are given below:

I PET 167f32×2
— fineness 167 dtex
— yarn diameter: 124 μm

II Kanebo coPET/PET 278f16

— fineness 278 dtex

— yarn diameter: 160 μm

The former is the yarn of the base knitted fabric in the artificial fur, and the latter is a meltable bicomponent filament. On the basis of the linear densities of the components, the content of meltable fibre in the doubled yarn (167 dtex + 278 dtex) results in 62.5 wt-%.

These filaments were combined with an annular doubling machine with a flat thread fillet (*e.g.* Z80). After this, the obtained yarn is **distributed** onto 12 bobbins with a flange winding machine, whereafter the artificial fur was manufactured with a single-cylinder circular knitting machine in the above-mentioned way.

The artificial fur indicated with the code T416 has the following structure:

— base knitted fabric
  · (167 dtex + 278 dtex)Z50 = 650 dtex
  · PET 167f32×2 + coPET/PET 278f16

— pile
  · PET Trevira T290, 3.3 dtex, 28 mm

The artificial fur containing meltable filaments is heated with a Benz continuous laboratory oven, whose upper valve (*Klappe*) is open *(auf)* and lower valve (*Klappe*) is closed *(zu)*. The actual test series comprises three different residence times. The surface density of the artificial fur is 320 g/m^2.

The temperatures and residence times used in the test series (FRAME 2) are given in Table 3.

Table 3. Values for air temperature and delay time in FRAME 2 test series.

Sample	Air temperature, ϑ_i (real value) [°C]	Sample temperature, ϑ (target) [°C]	Sample residence time, t_a (real value) [s]
Frame 1/2	160	155	145
Frame 2/2	180	160	90
Frame 3/2	200	160	65

A sample is placed the pile side down in a bracket (to be subjected to the effect of a hot air flow). The artificial fur must also be stretched in the sample bracket of the frame so that it is subjected to tensile stress. The pile side of the sample is protected with a heat-resistant material, *e.g.* a cloth with an aluminium coating.

The test result is given in Fig. 7. The first number after the product code T416 indicates the treatment temperature, and the second number the residence time. The fastening of the pile of the artificial fur improves with the thermal treatment. It seems that the meltable fibre has a better effect in the pile (Fig. 5) than in the base knitted fabric (Fig. 7). When the meltable fibre is in the base knitted fabric, the feel of the pile remains soft in spite of the thermal treatment.

Embodiment example 4: Fixing of the pile of the artificial fur with a plastic film

The artificial fur was made with a single-cylinder circular knitting machine. This artificial fur indicated with the product code T513 has the following structure:

artificial fur structure (no meltable fibre in the pile):
· base knitted fabric: PET 167/32×2 100%
· PILE: Dacron T688 (35 mm) 35%, 8 mm
Dralon BRT (28 mm) 65%, 8 mm

The pile consists of a blend of polyacryl Dralon L BRT 3.3/28 (Bayer) and polyester Dacron T688 4.7/35 (DuPont), that is, it does not contain a component meltable at the treatment temperatures. The basis weight of the artificial fur was 350 g/m^2. Unglued artificial fur was coated with a breathable plastic coating protecting from wind and rain. With the plastic film, the pile of the artificial fur is bound to the base knitted fabric.

A thermoplastic film was laminated on the surface of the base knitted fabric of the artificial fur. The following film qualities were used in the test:

I Porelle 55 (Porvair PLC)
- polyether urethane
- perforated film
- average hole diameter (∅): 1 µm
- film thickness: 55 ± 5 µm
- non-transparent, white film
- resistance to hydrostatic pressure (BS 3424 method 29C): 700 cmH_2O/min = 0.69 bar
- permeability to water vapour (ASTM E96 B): 650 750 g/(m^2·d)

II Symbatex (Enka)
- polyester
- hydrophilic film
- film thickness: 10 µm
- transparent, colourless film
- resistance to hydrostatic pressure: > 1 bar
- permeability to water vapour: > 2500 g/(m^2·d)

III Pebatex (Elf Atochem)

- polyether amide
- hydrophilic film
- film thickness: 15 μm
- transparent, colourless film
- resistance to hydrostatic pressure (DIN 53886): > 1 bar
- permeability to water vapour (ASTM E 96 BW): 25 000 g/(m^2·d)

The films were fixed to the base knitted fabric of the artificial fur with a gluing press (Meyer KF600), in which the product was run between two heatable rubber bands. At the starting end of the line, the film was heated above the melting point, and at the terminal end, the film was fixed by compression to the surface of the fabric. The film was melted onto the surface of the artificial fur.

Three sample laminates were made. The bottom material of the laminates was artificial fur, onto which was thermally bound a film, impermeable to water in liquid state, but permeable to water vapour. When needed, thin adhesive web was used, whose material was polyurethane. The data on the adhesive web are given below:

- manufacturer: Applied Extrusion Technologies Ltd. (England)
- product name: Sharnet SH 151
- material: polyurethane
- melting range (DSC measurement): 110—145°C
- temperature range of lamination: 150—170°C.

The quality of the second adhesive web used was Sharnet SH 2402 which is a polyamide. The processing conditions are given in Table 4. The adhesive web was used in connection with hydrophilic films, *i.e.* the samples 2 and 3. Porelle films (sample 1) contain densely distributed adhesive points of a melting plastic which bind them to the product to be covered.

Table 4. Values for the air temperature, residence time and compression load in the test series.

Film	Temperature Upper belt (control value) [°C]	Sample residence time (real value) [s]	Sample compression load (control value) [N/cm^2]
Sample 1 / Porelle 55 / no adhesive web	140	22	9
Sample 2 /Symbatex/adhesive web: Sharnet SH 151	160	22	9
Sample 3 /Pebatex/adhesive web: Sharnet SH 2402	160	22	9

When a plastic film is laminated onto an artificial fur, unglued pile fibres are fixed to the base knitted fabric. This is evident from Fig. 8 which shows the effect of a laminated plastic film on the fastening of the pile when the artificial fur contains no meltable binding fibre. The reference samples are unglued artificial furs T351 and T513. The best is the sample which is laminated with a Symbatex film. The lamination of the plastic film will fully replace the adhesion of the pile of the artificial fur; at the same time, a breathing water-tight and air-tight product is obtained.

By means of a breathing plastic film protecting from wind and rain, the artificial fur can also be made impermeable to *e.g.* an air flow and water (Figs. 9 and 10). Figure 9 shows the effect of a laminated plastic film on the permeability of the artificial fur T513 to air, and Fig. 10 shows the effect of the laminated plastic film on the resistance to hydrostatic pressure. On the measurement results, it can be briefly stated that only the abrasion resistance of laminated samples is clearly poorer than that of glued artificial furs. The wear resistance of laminated samples can be improved by coating the plastic film with a very thin knitted or woven fabric or cloth. This makes it also possible to fashion the surface of the artificial fur with any pattern. Moreover, the feel of this product is fully

textile-like, *i.e.* better than with artificial furs bound with an adhesive emulsion.

The laminated samples are breathing, their permeability to aqueous vapour is the same as that of uncoated artificial fur T513. Furthermore, laminated artificial furs are air-tight, because they are not permeable to air in practice. The resistance of laminated products to hydrostatic pressure is more than 10 m; the corresponding value for glued artificial furs is only 1 to 5 cm. The best product throughout the whole series was the artificial fur coated with the Symbatex film.

Claims:

1. An artificial fur in which staple fibres (3) are mechanically mixed to a base knitted fabric (1) formed of a yarn (1a), to protrude from the level of the base knitted fabric (1) and to form a pile on the outer surface of the artificial fur, **characterized** in that the staple fibres (3) mixed to the base knitted fabric (1) are fixed to the base knitted fabric (1) by thermal binding by means of a plastic material softened and/or melted by the effect of heat.

2. The artificial fur according to claim 1, **characterized** in that the thermal binding is performed by means of staple fibres (3) mixed to the base knitted fabric (1) and comprising plastic material softened and/or melted by the effect of heat.

3. The artificial fur according to claim 1, **characterized** in that the thermal binding is performed by means of the yarn (1a) of the base knitted fabric (1) which comprises plastic material softened and/or melted by the effect of heat.

4. The artificial fur according to claim 2 or 3, **characterized** in that the thermal binding is performed by means of both the yarn (1a) of the base knitted fabric (1) and the staple fibres (3) mixed to the base knitted fabric.

5. The artificial fur according to claim 1, **characterized** in that the thermal binding is performed by means of an additional layer (2) placed on the reverse side of the base knitted fabric (1), comprising plastic material, softened and/or melted by the effect of heat, lying against the base knitted fabric (1).

6. The artificial fur according to claim 5, **characterized** in that also the yarn (1a) of the base knitted fabric (1) and/or the staple fibres (3) mixed to the base knitted fabric contain plastic material softened and/or melted by the effect of heat.

7. The artificial fur according to claim 2 or 4, **characterized** in that the staple fibres (3) mixed to the base knitted fabric (1) contain binding fibre whose component forms a plastic material softened and/or melted by the effect of heat.

8. The artificial fur according to claim 3 or 4, **characterized** in that the yarn (1a) of the base knitted fabric (1) comprises a binding fibre whose component forms a plastic material softened and/or melted by the effect of heat.

9. The artificial fur according to claim 2, 3, 4, 6, 7, or 8, **characterized** in that the staple fibres (3) mixed to the base knitted fabric, or the base knitted fabric (1), comprise also other fibre material in addition to the fibres containing plastic material softened/melted by the effect of heat.

10. A method for manufacturing an artificial fur according to any of the claims 1 to 9, **characterized** in that the thermal treatment is made by conduction heat.

11. The method according to claim 10, **characterized** in that the thermal treatment is made by passing the base knitted fabric (1), and an additional layer (2) possibly fixed on its reverse side, over a heated surface.

12. The method for manufacturing the artificial fur according to any of the claims 1 to 9, **characterized** in that the thermal treatment is made by convection heat.

13. The method for manufacturing the artificial fur according to any of the claims 1 to 9, **characterized** in that the thermal treatment is made by radiation heat.

14. The method according to any of the preceding claims 10 to 13, **characterized** in that in addition to the thermal treatment, also pressure is used in the fixing.

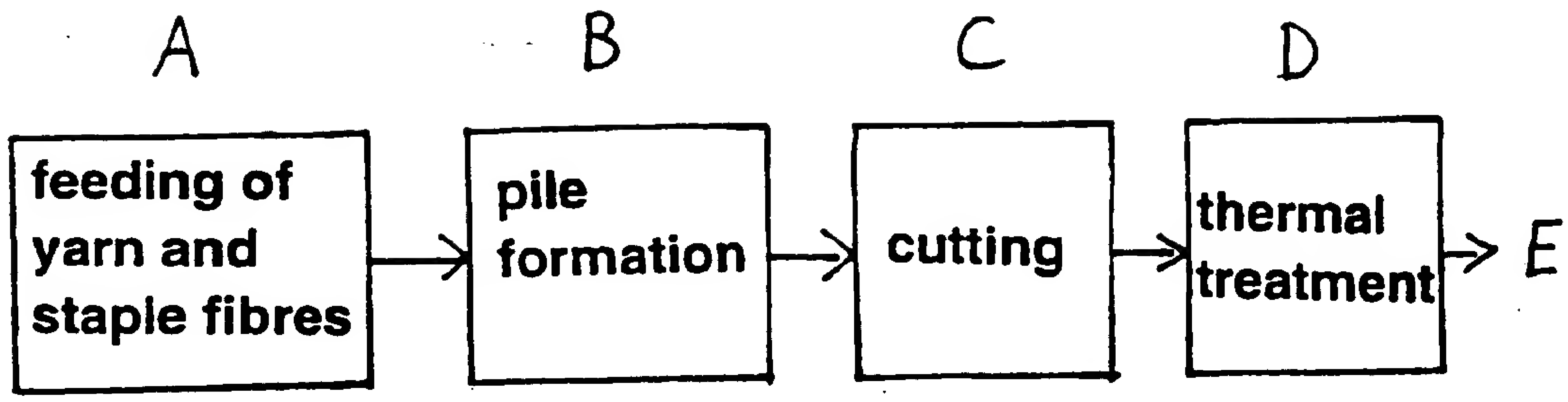


Fig. 1

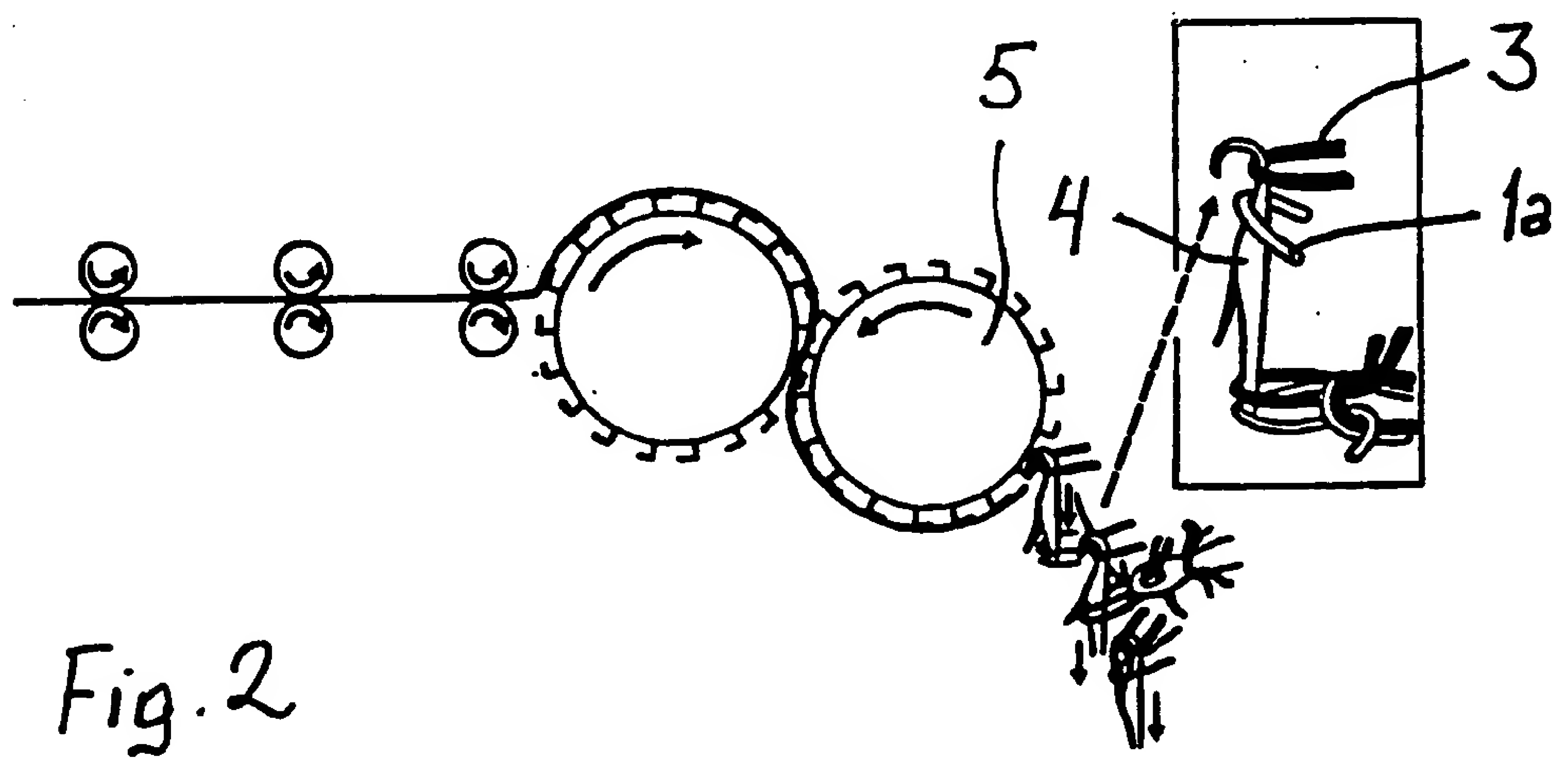
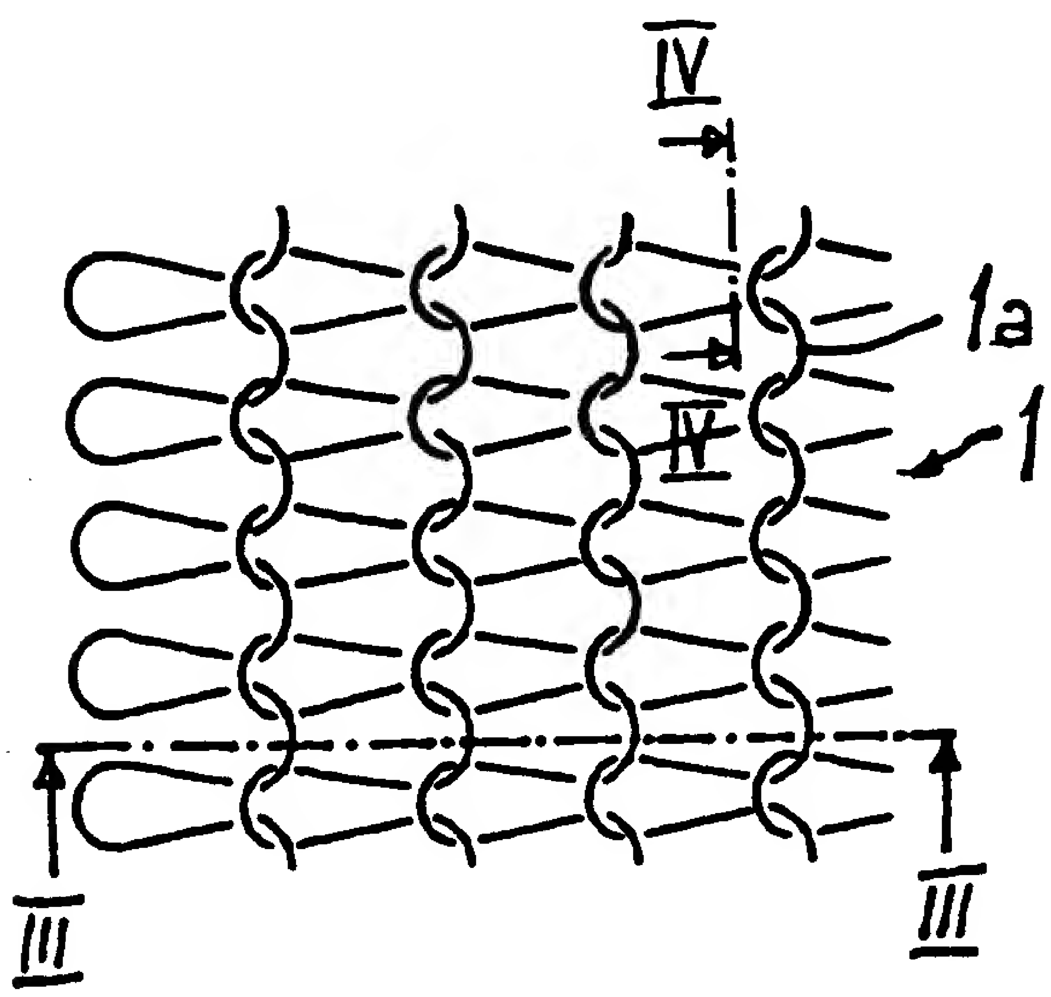


Fig. 2



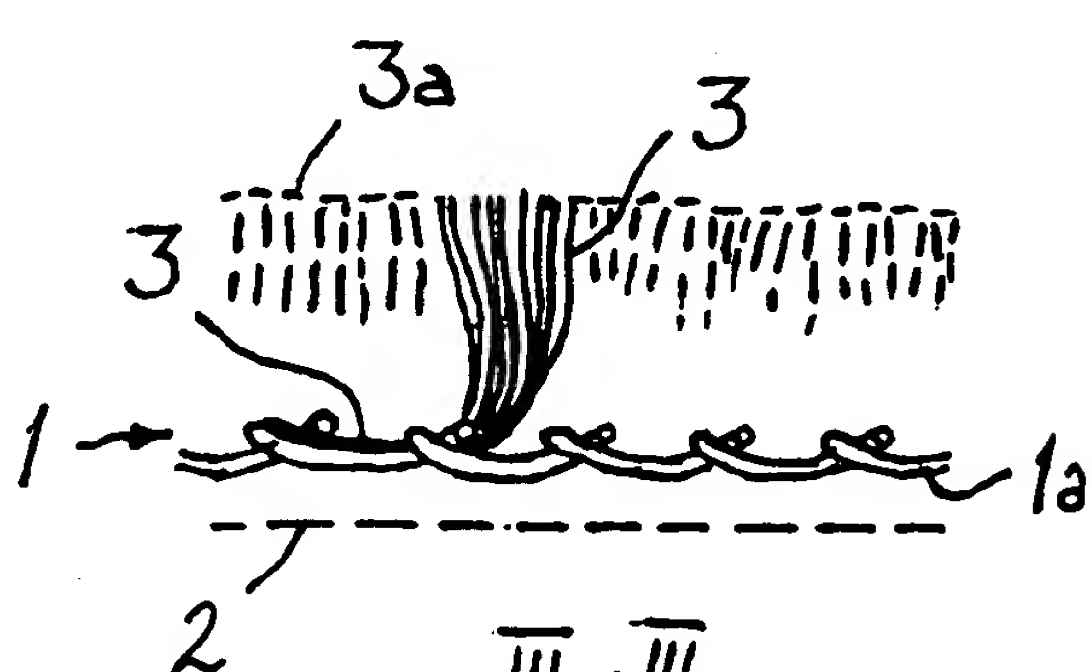


Fig. 3

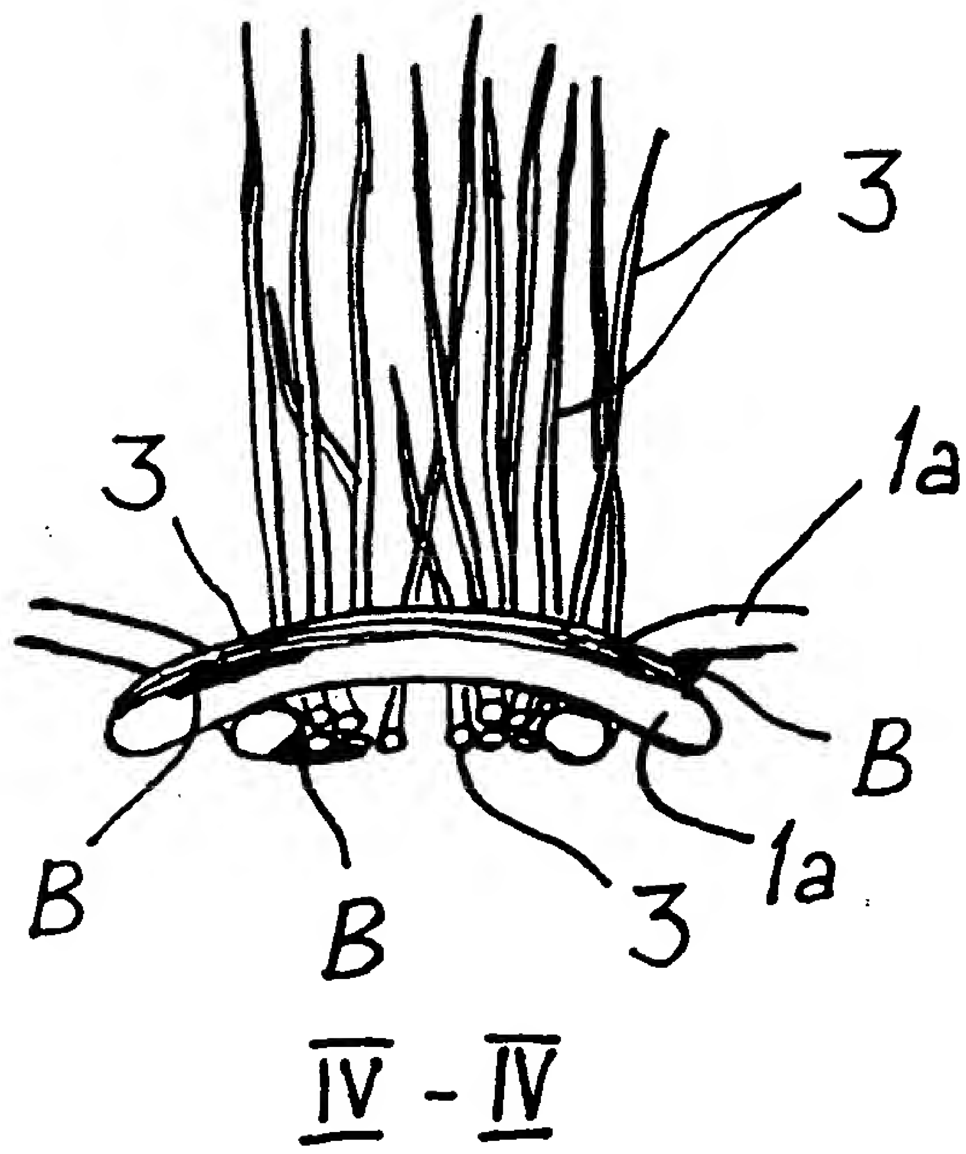


Fig. 4

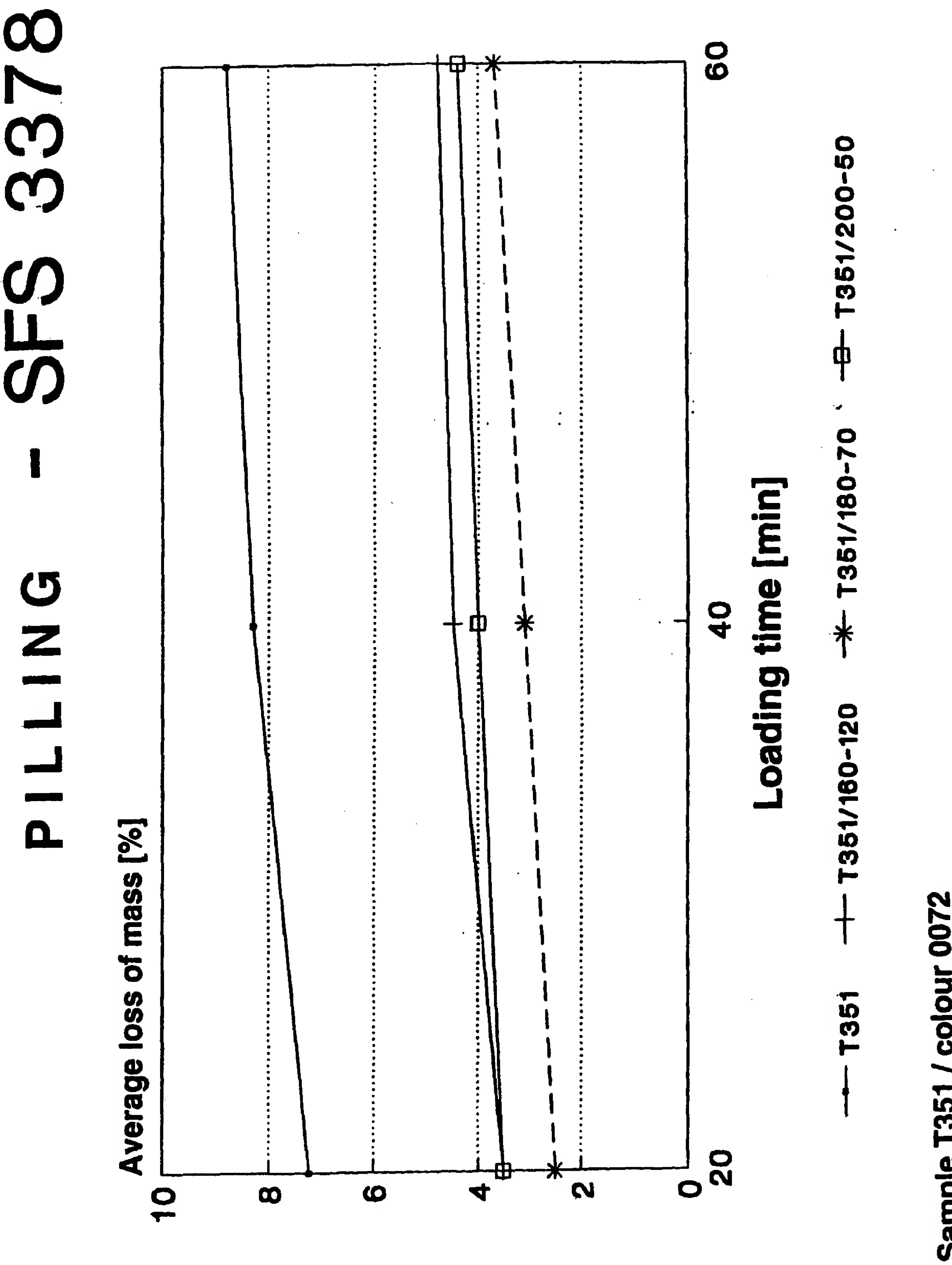
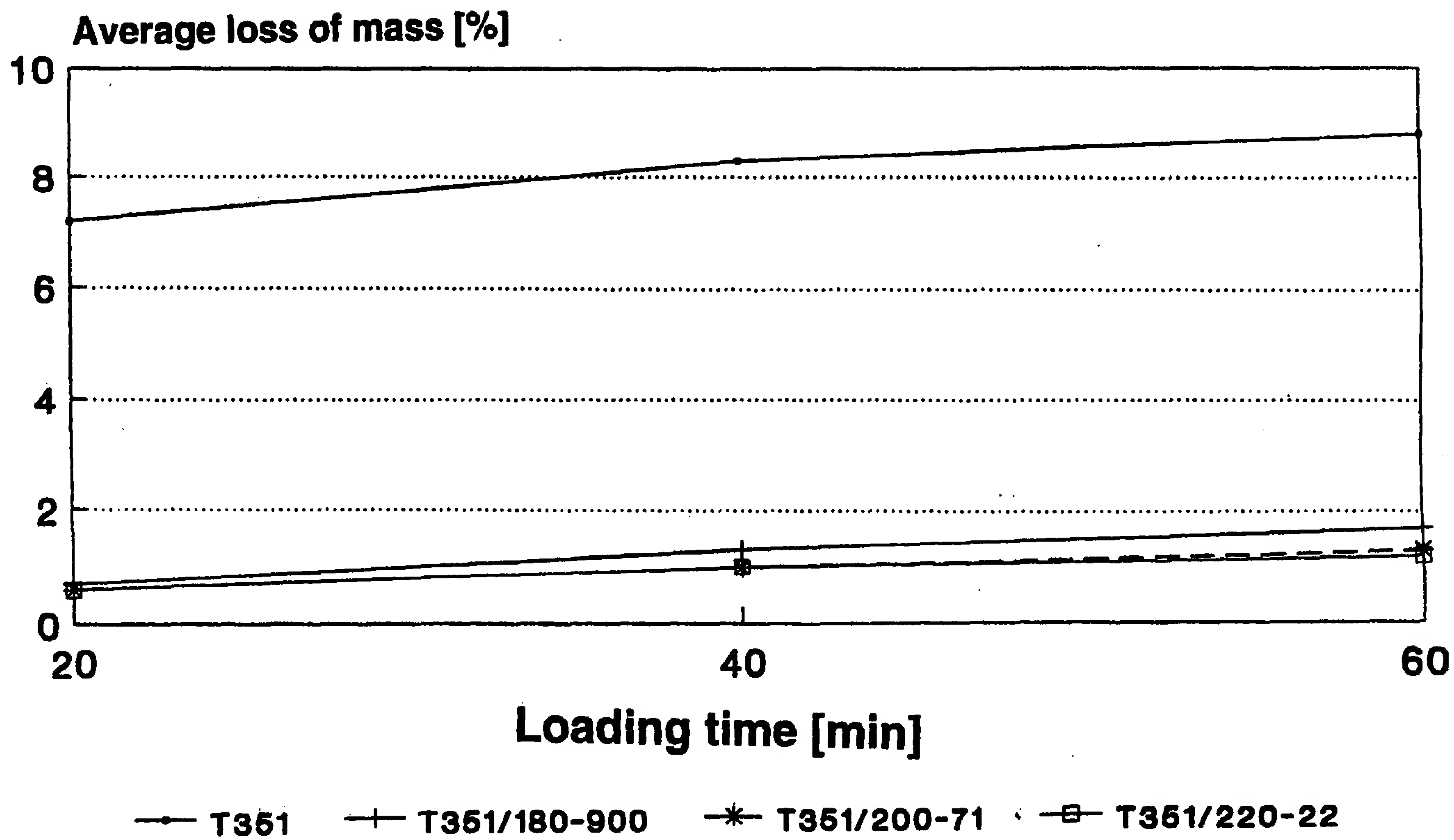

PILLING - SFS 3378
Average loss of mass [%]
10
8
6
4
2
0
20
40
60
Loading time [min]
T351
T351/180-120
T351/180-70
T351/200-50
Sample T351 / colour 0072

Fig. 5

PILLING - SFS 3378
FIXO



Sample T351 / colour 0072

Fig. 6

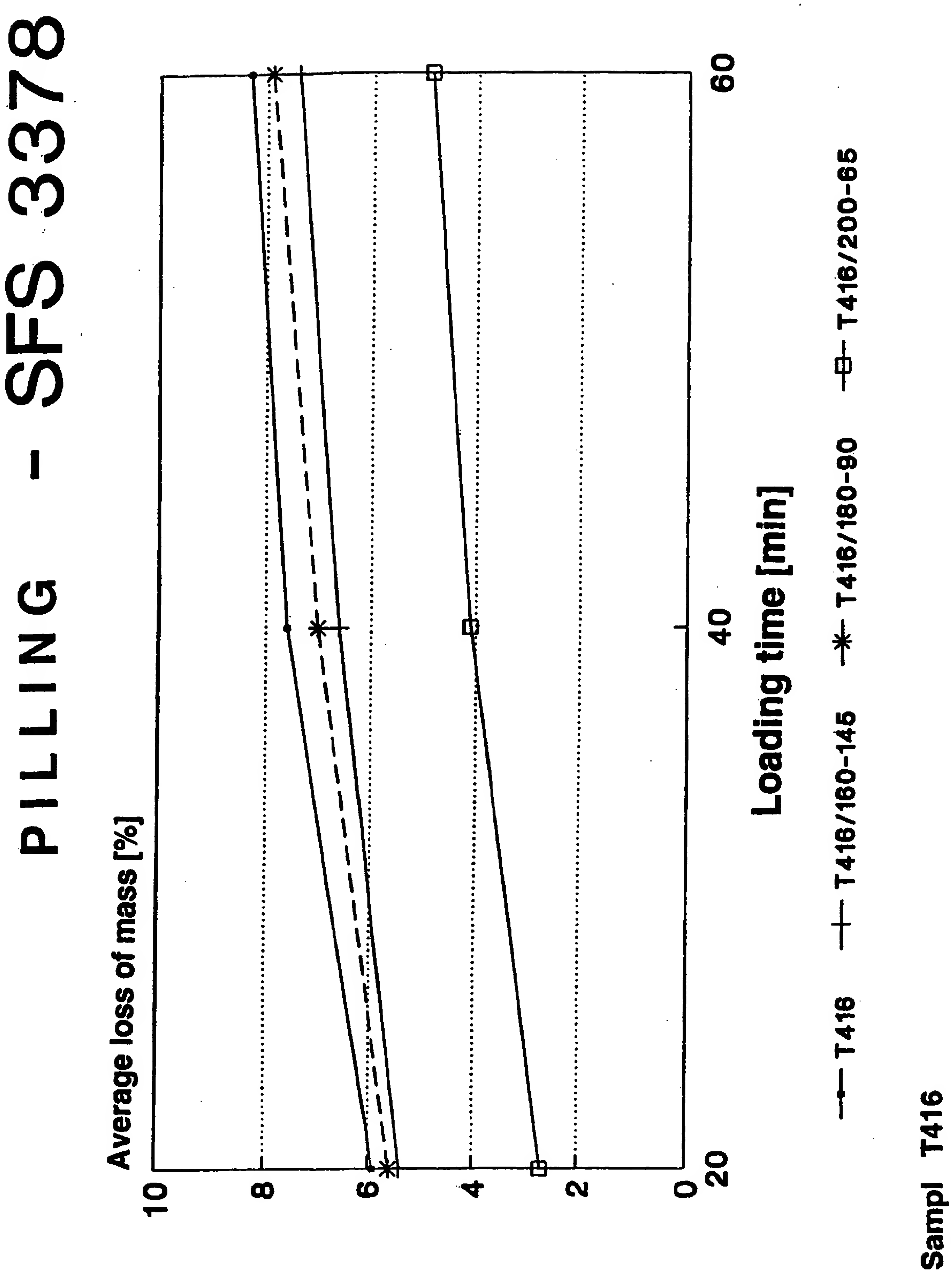

PILLING - SFS 3378
Average loss of mass [%]
10
8
6
4
2
0
20
40
60
Loading time [min]
T416
T416/160-145
T416/180-90
T416/200-65
Sampl T416

Fig. 7

PILLING - SFS 3378

Effect of plastic film

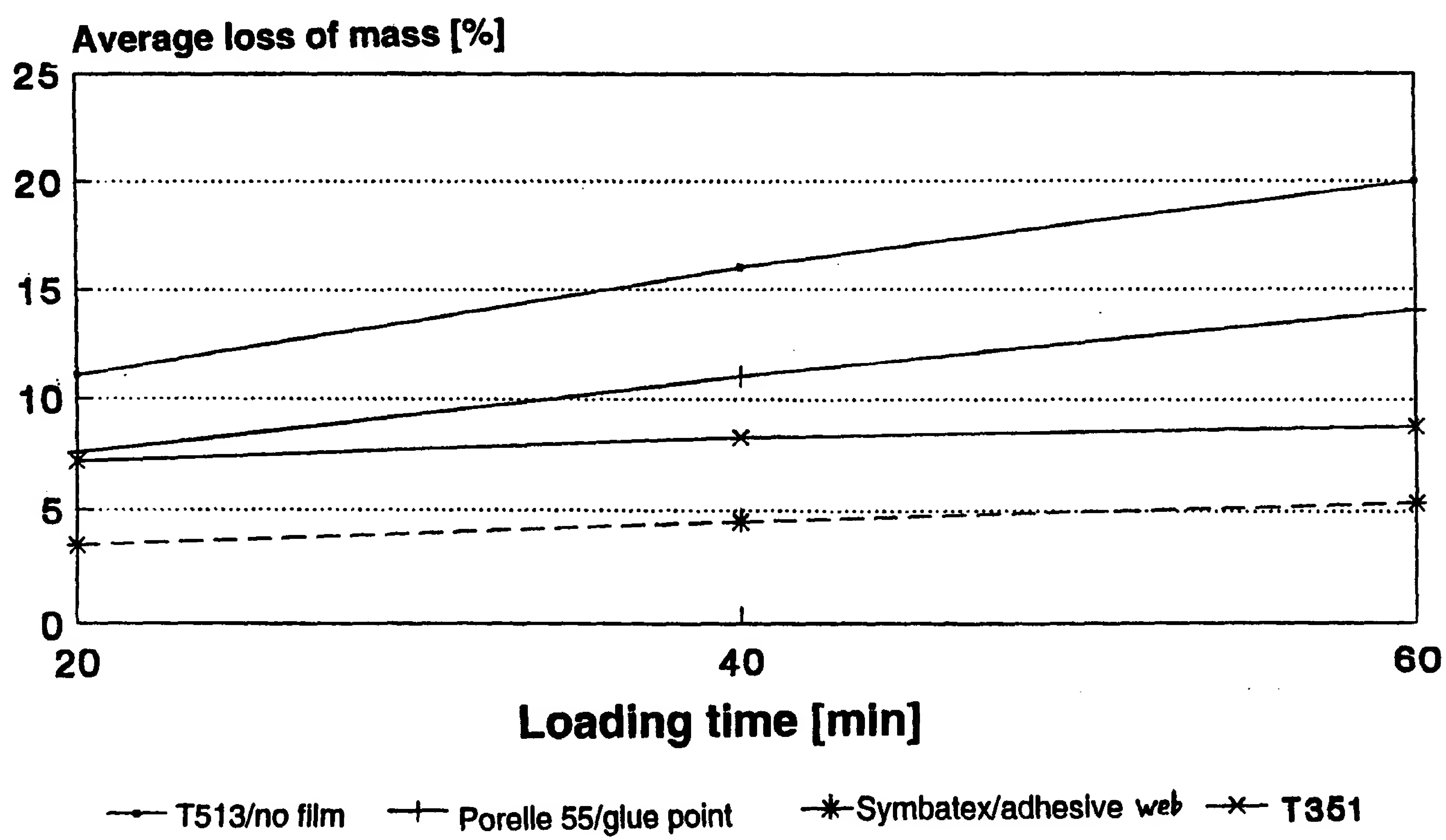


Fig. 8

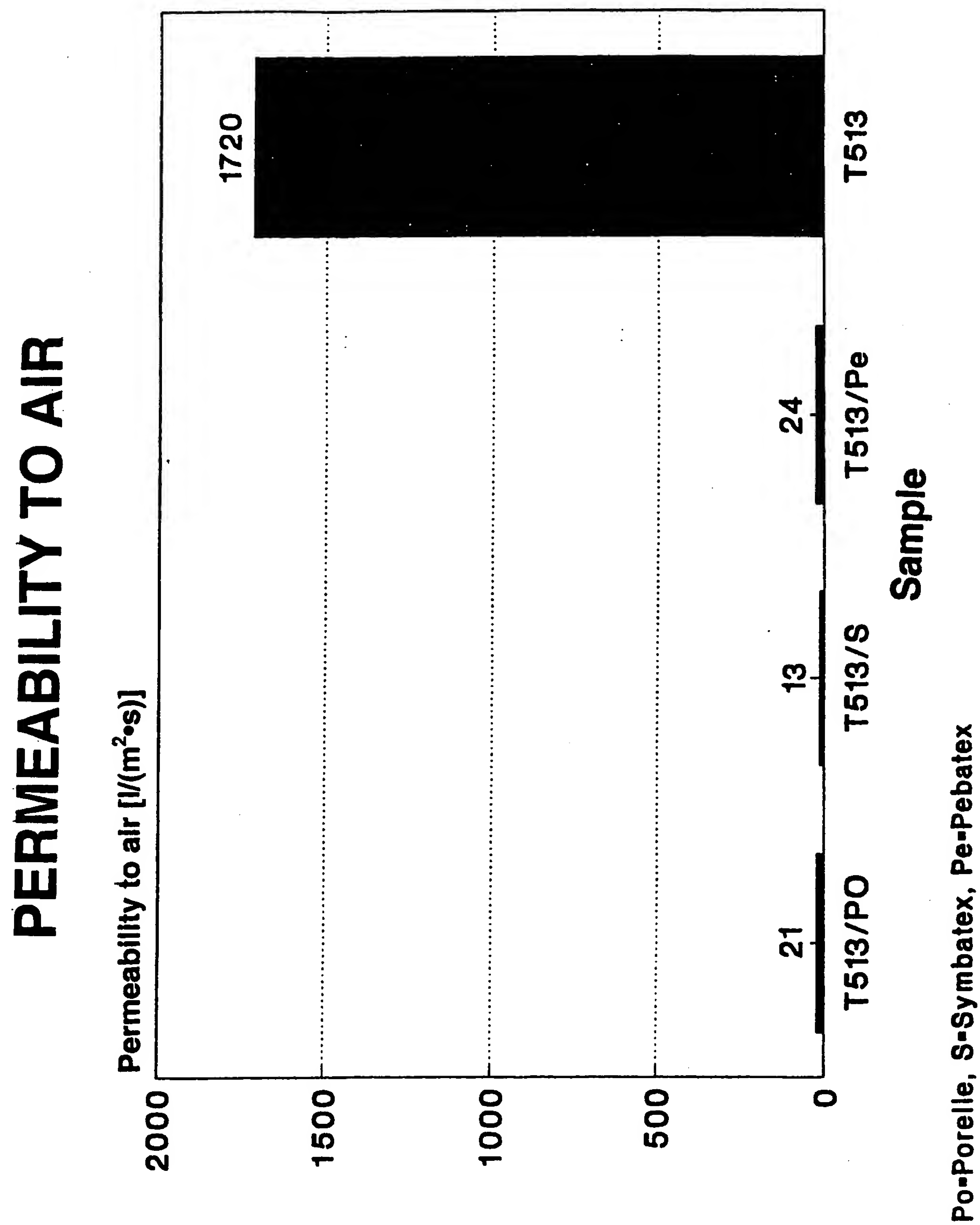

PERMEABILITY TO AIR
Permeability to air [l/(m²•s)]
2000
1500
1000
500
0
21
13
24
1720
T513/PO
T513/S
T513/Pe
T513
Sample
Po-Porelle, S-Symbatex, Pe-Pebatex

Fig. 9

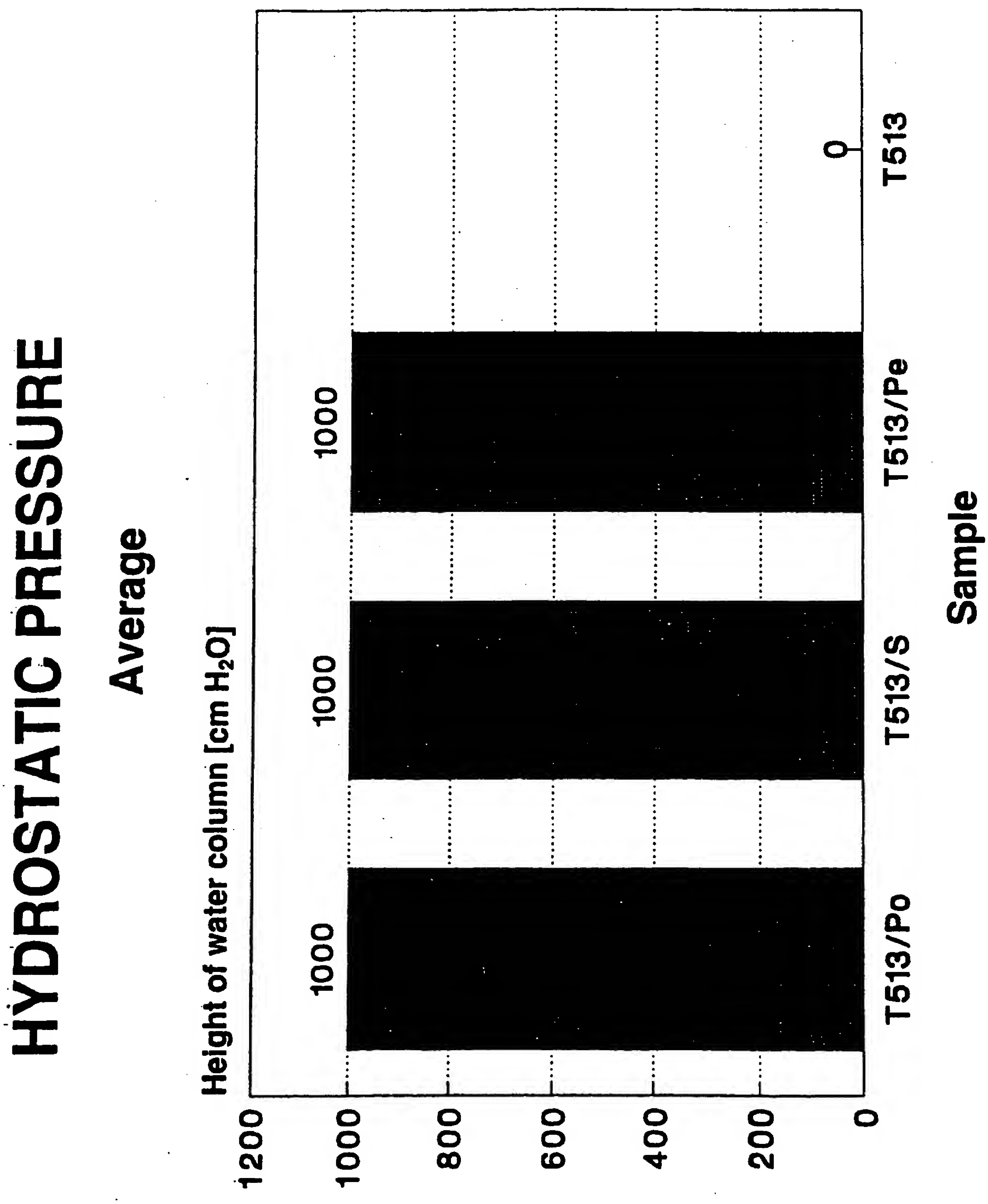


Fig.10

Po-Porelle, S-Symbatex, Pe-Pebatex

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00023

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D03D 27/00, D04H 11/00, D04H 1/54, D04H 1/48

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: D04H, D03D, A41D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5630896 A (J.A. CORBIN ET AL), 20 May 1997 (20.05.97), column 1, line 18 - line 35; column 2, line 23 - line 33; column 2, line 58 - line 64, column 3, line 1 - line 27, column 4, line 18 - line 21, column 4, line 41 - line 48	1-9
Y		10-14
	--	
Y	US 4935077 A (B. ELLERS), 19 June 1990 (19.06.90), abstract	13
	--	
Y	EP 0591609 A1 (BASF CORPORATION), 13 April 1994 (13.04.94), page 2, line 49 - line 55; page 3, line 5 - line 11; page 3, line 25 - line 45	10-12,14
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" erlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 August 1999	16 -09- 1999
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Teija Kurki / MR Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00023

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4236286 A (N.C. ABLER ET AL), 2 December 1980 (02.12.80), figures, abstract --	1-9
A	US 3755057 A (H.L. SCOTT), 28 August 1973 (28.08.73), column 1, line 47 - column 2, line 38, figures, abstract --	1
A	Patent Abstracts of Japan, abstract of JP 6-192958 A (TORAY IND INC), 12 July 1994 (12.07.94), the whole document -- --------	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

02/08/99

International application No.
PCT/FI 99/00023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5630896 A	20/05/97	US 5532035 A	02/07/96
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		AU 3820493 A	04/11/93
		BR 9301703 A	03/11/93
		CA 2094875 A	02/11/93
		CN 1084119 A	23/03/94
		DE 69320240 D,T	24/12/98
		EP 0568916 A,B	10/11/93
		SE 0568916 T3	
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